Chapter 1
Introduction

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BATIQUITOS LAGOON ENHANCEMENT PROJECT
LONG-TERM BIOLOGICAL MONITORING PROGRAM
FINAL REPORT

1.0 INTRODUCTION

This is the final report for the Batiquitos Lagoon Enhancement Project Long-term Biological Monitoring Program and Pilot Eelgrass and Cordgrass Revegetation. The report provides a summary of the investigations completed within the lagoon before and following restoration, documents the lagoon ecosystem development that occurred as a result of restoration, and analyzes changes in the system throughout the monitoring period.

1.1 RESTORATION PROGRAM BACKGROUND

1.1.1 Lagoon History

Batiquitos Lagoon is an approximately 600-acre coastal lagoon located in the City of Carlsbad in San Diego County, California (Figure 1-1). It is bounded by Pacific Coast Highway/Carlsbad Boulevard on the west, La Costa Avenue on the south, El Camino Real on the east, and Batiquitos Drive and the Aviara Community to the north (Figure 1-2).

Like the other coastal lagoons of southern California, it is not a true lagoon in the geomorphologic sense, but rather a flooded river valley estuary. The valley was deeply incised during the middle to late Quaternary period when sea level was 300 to 400 feet below present elevations. The valley was subsequently claimed by the rising sea over the past 18,000± years. Early during this time, the rapid rise of sea level created an estuary dominated by marine influences. As the rise in sea level slowed over the past 5,000 years, several factors resulted in significant changes to the lagoon geomorphology and ultimately its hydrologic character. First, the gradual, albeit punctuated, scouring flows and discharge of fluvial sediments to the eastern end of the lagoon resulted in shallowing of the lagoon and sculpting of the bed geometry to create an elongated coastal wetland flanking both the northern and southern shorelines of a relatively straight open water tidal basin.

Less than 150 years ago, the lagoon was regularly open to persistent tidal influence. However, the lagoon changed significantly with the arrival of European settlers. Roads and railroads were built across the lagoon restricting water flows and retarding storm flow sediment purges. Watershed agriculture and development activities increased sediment loads discharged to the system. Portions of the lagoon were diked and filled for salt evaporation ponds, duck hunting, and ultimately development, while watershed changes included damming and diversions of creek flows, as well as other significant hydromodifications. All of these alterations combined to drastically alter the lagoon condition as is documented in the Batiquitos Lagoon Enhancement Plan (California Coastal Conservancy 1987). Finally, during the 1970-1990s there was a diminishing sand supply on the beaches resulting in an increasing ratio of cobble to sand within the littoral cell. This increasing cobble fraction exacerbated the formation of stable closure sills at the mouth of the lagoon. The local changes in the lagoon, combined with changes in the watershed and littoral cell, set in motion physical evolutionary processes resulting in a rapid

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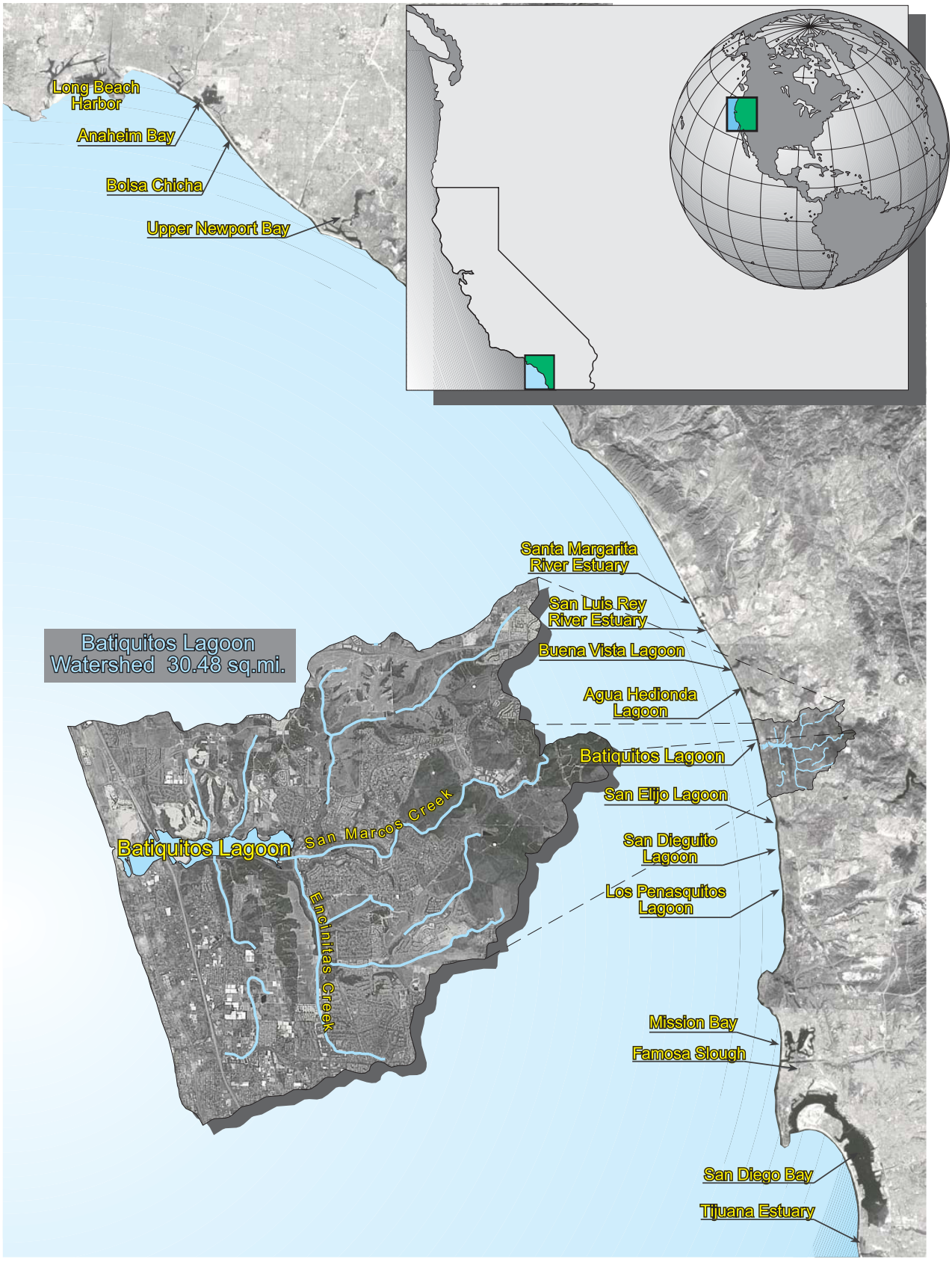

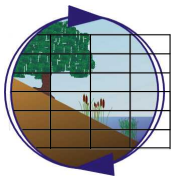

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Batiquitos Lagoon regional vicinity map

Figure 1-1

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Batiquitos Lagoon local vicinity map

Figure 1-2

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deterioration of the lagoon from a typically open lagoon to a normally closed system. In 1978, the California Department of Fish & Game (CDFG) purchased 135 acres of the lagoon and commenced tracking mechanical lagoon mouth openings. From 1979 through the initiation of lagoon enhancement in 1993, there were at least eight mechanical openings of the lagoon for flood control or habitat management (T. Dillingham, CDFG unpublished data). There may have been openings during the remaining years or multiple openings during the years; however, older records are incomplete.

The lagoon had been altered to a degree that its capacity to naturally reestablish tidal influence was lost due the reduction in its tidal volume. With its typically closed coastal inlet, Batiquitos Lagoon became an immense settling pond for sediment, watershed nutrients, and other pollutants. During the wet season, the lagoon filled with freshwater and fluvial sediments. Spring and summer ephemeral algal blooms were an annual occurrence, and the water quality of the system was typically very poor. Wild diurnal fluctuations in dissolved oxygen, salinity, temperature, and pH were common and resulted in occasional fish die-offs. As creek flows diminished in the summer months and evapotranspiration rates increased, the ponded lagoon would generally dry to different degrees. This led to high odors as the algal mats decayed and contributed a biogenic source of organic muck to the lagoon sediments. Local residents reported lagoon odors that could be detected for several miles on some days. It eventually developed many unflattering monikers such as “scunge lake”.

Algal mats on Batiquitos Lagoon east basin in mid-August prior to restoration.

Batiquitos Lagoon east basin in July 2005 post-restoration.

Batiquitos Lagoon was approaching full eutrophication and eventual conversion to an upland environment. By the mid-1980s, the lagoon was so highly degraded that it supported principally ephemeral aquatic resources and opportunistic wetland communities that fluctuated in abundance and distribution depending upon climatic variability and periodic opening of the lagoon to oceanic drainage. In some years, the lake-like lagoon provided significant habitat value for over-wintering waterfowl. As water levels fell across the non-tidal flats and in shallow ponded areas, shorebirds fed on insects and aquatic invertebrates. While the summer drying of the ponded lagoon was generally detrimental to aquatic resources and an odor nuisance to surrounding residents and coastal visitors, it did expose broad mudflats and salt flats that provided foraging areas for migrating shorebirds and were used for breeding by terns, plovers, and marsh birds. In those winters when the lagoon was flooded, it provided foraging habitat for migratory waterfowl. Three threatened or endangered species, the California least tern (*Sternula antillarum browni*), the western snowy plover (*Charadrius alexandrinus nivosus*), and the Belding's Savannah sparrow (*Passerculus sandwichensis beldingi*) made use of the lagoon environment; however, the fluctuating lagoon water levels made availability of nesting and foraging habitat unpredictable from year to year. As a result, consistent and major use of the area for nesting by these species did not occur.

Absent any restoration action, the lagoon was predicted to be significantly filled with sediment within 40 to 50 years (City of Carlsbad and U.S. Army Corps of Engineers 1990). Predictions made regarding the sedimentation rates were that nearly all portions of the lagoon below 0 feet mean lower low water (MLLW) would be lost over the next 40 to 50 years. Areas from 0 to 5 feet MLLW would be diminished in area by 40 to 77%, and areas between 5 and 7 feet MLLW would be reduced in area by 16 to 22%. This loss of low elevation would result in more frequent closures and more rapid re-closures following mouth openings. It would result in loss of aquatic habitats, particularly those of a semi-marine nature, and it would exacerbate local area flooding.

The inconsistent availability of habitat resources, the highly degraded aquatic environment, and the recognition that the system was continuing to rapidly decline made the lagoon a strong candidate for intervention. Along this line, in the 1980s, a developer proposed residential development at the lagoon, including dredging and developing an inlet to support a marina. However, due to financial difficulties and under pressure from the public, resource, and regulatory agencies, the developer deeded over most privately held portions of the lagoon to the State of California in an agreement that would secure development rights in the uplands along the north shore of the lagoon. The acquisition of portions of the lagoon that were not already State-owned paved the way for restoration planning and ultimate implementation.

1.1.2 Pre-Restoration Activities

In 1985, an enhancement group formed, and the California Coastal Conservancy began the process of preparing an enhancement plan for Batiquitos Lagoon. The Draft Enhancement Plan was completed in 1987; the primary goals of the plan were to enhance Batiquitos Lagoon for wildlife habitat and to open the lagoon to tidal action while retaining migratory bird habitats to the greatest degree feasible (California Coastal Conservancy 1987). Restoration would be achieved by dredging to produce shallow subtidal and intertidal habitats, restoring adequate tidal prism to maintain an open mouth and provide good tidal circulation, and developing permanent nesting sites within the lagoon to support least tern use.

As the enhancement plan was being developed, the resource agencies approached the Port of Los Angeles (Port) with the concept of restoring the lagoon as mitigation for a proposed Port development in Los Angeles Harbor. In 1987, the Port, City of Carlsbad (City), CDFG, California State Lands Commission (CSLC), National Marine Fisheries Service, and U.S. Fish & Wildlife Service (USFWS) entered into a memorandum of agreement to establish a project for compensation of 381 acres of marine habitat losses incurred by Port development landfills within Los Angeles Harbor through marine habitat enhancement at Batiquitos Lagoon. The Batiquitos Lagoon Mitigation Agreement provided that the Port would fund all restoration activities including: preliminary design, environmental review, final design, construction, and monitoring. The City was to be lead for environmental review, obtaining necessary permits and overseeing the construction and long-term establishment monitoring. Finally, the lagoon would be leased to CDFG by the CSLC and maintained as a State Ecological Reserve in perpetuity. The CDFG would be responsible for on-going maintenance and operations of the lagoon using an interest-bearing maintenance fund established by the Port.

A lengthy process of preliminary engineering, alternatives consideration, and environmental review began in 1987 and extended through August 1990. During this process, no less than 10 full alternatives were considered, along with many hybrid options. At the end, the restoration alternative selected through the environmental process (mitigated Alternative B) was selected because it offered the best balance of ecosystem enhancement with protection of the existing lagoon and coastal resource values. A Technical Review Committee of experts in sediment transport, tidal inlet design, dredging methods, wetland biology, oceanography, and coastal structures was assembled in 1990 to review the selected alternative and provide technical input to refine the design plan. The selected project alternative made use of an innovative sediment management solution that increased beach sand nourishment volumes, while minimizing export costs and impacts of fine sediments that were not compatible with beach nourishment uses. The project included the over-dredging of sand from the deep littoral deposits within the central basin of the lagoon to create a 38-foot deep in-bay disposal pit into which fine sediments from the east basin were pumped. The disposal pit was subsequently capped with clean littoral sands from the dredging of the west basin. This sediment management activity resulted in approximately 1.8 million cubic yards of beach sand being placed into the Carlsbad coastal littoral cell, construction of bird nesting sites, and no export of fine sediments to landside or ocean disposal sites.

With the selection of a preferred alternative, a four-year process of final design, permitting, and contracting was undertaken between 1990 and 1994. Principal environmental regulatory permits issued for the project included a Clean Water Act section 404 permit for deposition of dredge and fill materials into waters of the U.S. and a California Coastal Act, Coastal Development Permit. During the permitting phase of the project, two lawsuits were filed in state and federal court challenging various aspects of the project on environmental grounds. Both legal challenges were rejected by the courts and the restoration project moved forward to construction.

1.1.3 Lagoon Restoration Implementation

Lagoon restoration work began on March 15, 1994 and was completed under the managing partnership of the City and the Port. Work entailed a sequential process of dredging and infrastructure improvements. The major construction process is outlined in Figure 1-3 (adapted from Appy 1997) and included: 1) dredging sand from the central basin, located

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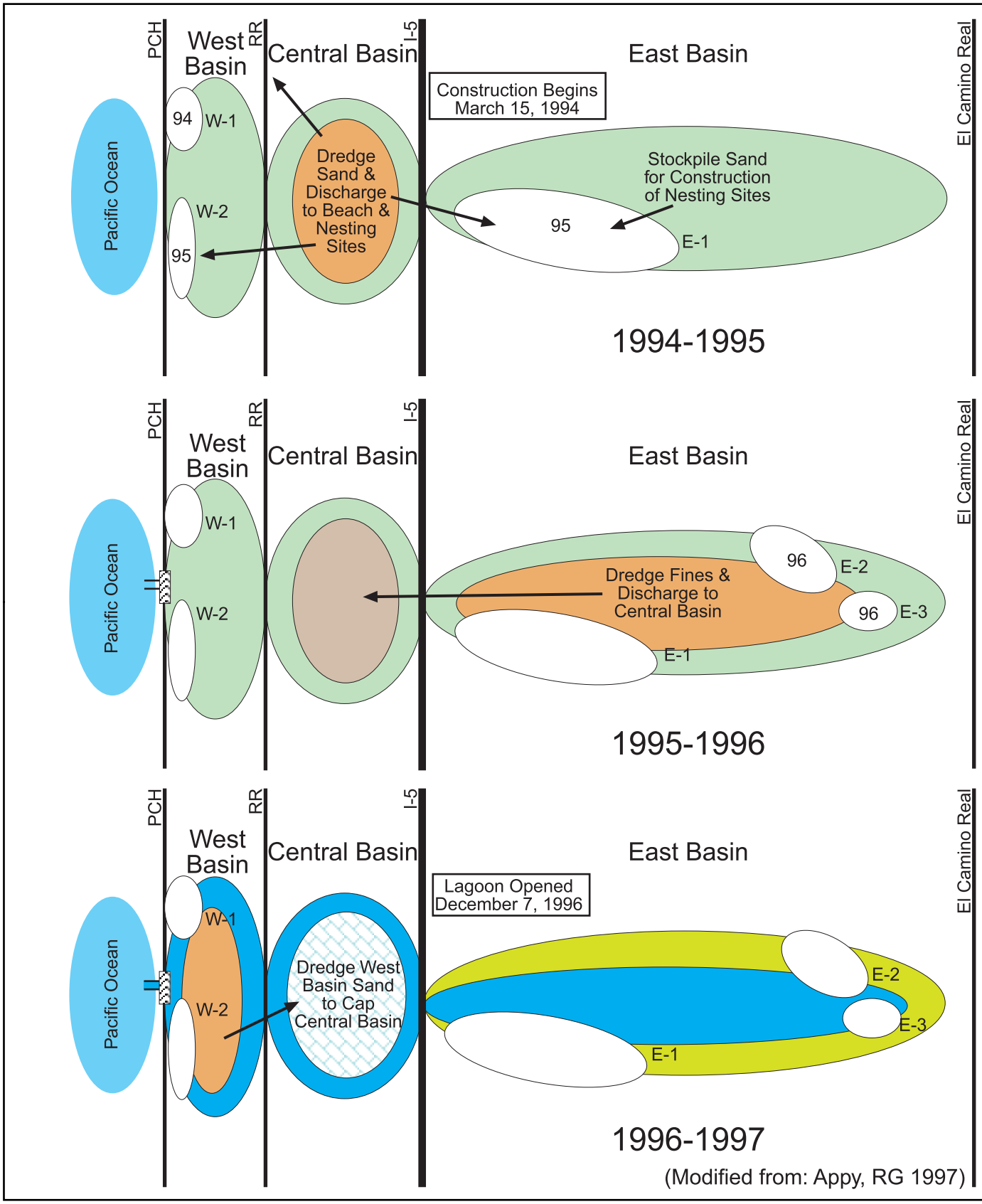

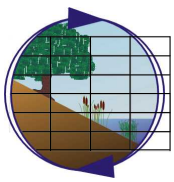

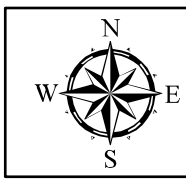

Batiquitos Lagoon restoration sequence

Figure 1-3

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between the North County Transit District railroad trestle and Interstate 5 (I-5), for use in beach replenishment and creation of tern colonies in 1994-1995 and to create a borrow pit in the central basin; 2) placement of fine materials dredged from the east basin, located east of I-5, into the central basin borrow pit and construction of the lagoon mouth jetties in 1995-1996; and 3) capping the central basin borrow pit that had been filled with fine sediments with sand dredged from the west basin, between Pacific Coast Highway (Carlsbad Boulevard) and the railroad. On December 6, 1996, the restoration was completed with the opening of the lagoon mouth to reestablish continuous tidal flushing (Figure 1-4).

Following restoration, physical calibration studies were undertaken to ensure the system was operating as anticipated and to assess stability of the tidal inlet (Moffatt & Nichol 1997). The maintenance account amount was established and funded at $8.4 million in accordance with the requirements of the Batiquitos Lagoon Mitigation Agreement. On June 1, 1997, the CDFG took over maintenance responsibilities for the lagoon and now manages the site as a State Ecological Reserve. A Draft Land Management Plan for Batiquitos Lagoon Ecological Reserve was prepared by CDFG in May 1997 outlining operations and maintenance tasks needed to address biological and public use elements, including maintenance of nesting sites, enforcing access restrictions, and implementing a physical and biological monitoring program (CDFG 1997). The draft plan was never finalized, and only some elements were implemented.

The implementation of the lagoon restoration project resulted in a visually striking conversion of the lagoon from a seasonally flooded or dry and erratically behaving wetland system to a principally open water lagoon with consistent tidal circulation and intertidal mudflats and salt marsh. Factors such as reduced odors, improved aesthetics, reduced upstream flood risks, and enhanced surrounding land values were unquantified, but important, community benefits of the lagoon restoration. A 10-year biological monitoring program was initiated to truly characterize the performance of the restored system.

1.2 THE LONG-TERM MONITORING PROGRAM

During the environmental review and permitting process for the enhancement project, a long-term biological monitoring and pilot revegetation program was determined to be necessary to document the biological effects of lagoon restoration. In addition, the monitoring program was meant to assist in providing information that would benefit management actions taken by CDFG. The long-term monitoring program that is the subject of this report was conducted for the City and the Port by Merkel & Associates, Inc. (M&A) in conjunction with Science Applications International Corporation (SAIC), Kawasaki, Theilacker, Ueno + Associates (KTU+A), Keane Biological Consulting, and Wetlands Research Associates (WRA).

The Batiquitos Lagoon Enhancement Project is unique in several respects. It represents an extensive, system-wide habitat rehabilitation project. Seldom have such opportunities existed for observing system-wide ecosystem development from a quantified baseline. In recognition of these factors, the long-term monitoring program for Batiquitos Lagoon was developed through project concept design and the environmental review process, in conjunction with project permitting as well as a memorandum of agreement between the City, Port, and state and federal

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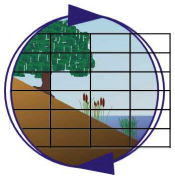

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Batiquitos Lagoon after restoration

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resource agencies. This monitoring program spanned a 10-year period, with monitoring efforts occurring in 1997, 1998, 1999, 2001, and 2006 (years 1, 2, 3, 5, and 10 post-construction). Limited additional sampling occurred in 2003 and 2005. Separate endangered species monitoring programs have been on-going at the lagoon since before its restoration, and a separately funded bathymetry and tide study was performed in 2008. Although these programs were reported on as separate efforts, all available data are summarized within this final report to provide continuity and completeness in the lagoon-reporting program.

The program reported on in the present document addresses primarily biological monitoring tasks. The Batiquitos Lagoon Enhancement Project Long-term Monitoring Plan that is included in the Draft Land Management Plan for Batiquitos Lagoon Ecological Reserve (CDFG 1997) calls for additional monitoring. It specifies physical monitoring to be conducted in parallel with the biological monitoring in years 1, 2, 3, 5, and 10, including twice-yearly bathymetric surveys in the inlet and west basin, annual bathymetric surveys in the east basin, continuous tidal monitoring, water current monitoring, from November to April, and beach and inlet surveys coincident with the bathymetric surveys. This portion of the Monitoring Plan was to be conducted by CDFG; however, it was not implemented and will therefore not be included in the present report.

1.3 PURPOSE OF THE FINAL REPORT

The long-term monitoring program for the lagoon consisted of quarterly, biannual, and annual sampling activities completed during each year of monitoring activity. These sampling intervals were documented through the production of quarterly data summary reports and annual reports. The quarterly reports served as a tool for contract management and provided regular and timely information with respect to development of the physical and biological system. The annual reports provided a data presentation and analysis format for assessing the status of the restoration project and evaluating changes in the site over the course of the year. Each annual report included a compilation of information collected for the specific year of sampling. The reports further provided an analysis of data for the specific year and a cumulative analysis of change in the system, making use of information from preceding years. The annual reports provided information and interpretations for in-process review of the status of Batiquitos Lagoon.

The present final report takes a broader look at the past decade since the restoration of the lagoon. To assess the relative performance of Batiquitos Lagoon as a southern California coastal wetland, extrinsic qualitative comparisons were made with other coastal bays, lagoons, and estuaries. Information from additional monitoring and sampling programs has been reviewed, and mechanisms for lagoon development have been explored. The final report seeks to accomplish the following:

- Document studies and surveys conducted and summarize sampling methods
- Summarize and provide aggregate information in an interpretable format

- Present an analysis of the data and provide an evaluation of the ecological development of the lagoon system

- Document habitat values achieved through restoration efforts

- Assess system compliance with regulatory permit mitigation requirements, and

- Make recommendations regarding beneficial actions that could be taken within the lagoon system that would continue to promote desirable ecosystem development.

This report details the methods and summarizes the data from sampling and enhancement efforts completed in all years of the Long-term Biological Monitoring and Pilot Revegetation Program for the Batiquitos Lagoon Enhancement Project from 1997 to 2006. Investigations conducted include those to document vegetation, fish, benthic, and avian communities. In addition, the outcome of pilot transplants of eelgrass (*Zostera marina*) and cordgrass (*Spartina foliosa*) are documented.

Measurement units of numerical data from the monitoring program are presented as a combination of metric and English Standard System units in this report. Typically, collected scientific data would be reported using metric units such as hectares and centimeters. The lagoon has a long regulatory, engineering, and biological monitoring history, however, that has made use of a blend of metric and English units. As a result, presentation of data has sought to continue using the units of measure that are most applicable to the various monitoring elements. Past presentation of the Batiquitos Lagoon data sets have revealed that reporting in metric units for some parameters is less useful than using English units. This is particularly true in reporting on area measurements and tidal elevations. In general, intended audience for this report may be better able to envision areas as acres, rather than hectares, and tides in feet, rather than meters. Therefore, in the following chapters where an area measurement has been made through GIS-based mapping efforts, the results are presented in acres. Similarly, tidal data are presented in feet, rather than meters, due to the greater familiarity of most readers with tidal ranges in feet and the historic usage of English units for these elements of the project. All other data, primarily measurements taken in the field, are reported in metric units.

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